Economic Evaluation of Road Traffic Safety Measures

Ejaz Gul

School of Civil and Environmental Engineering, National University of Science and Technology, Islamabad, Pakistan

16. July 2013

ISBN 978-969-8620-10-3

Proceedings of IEDC 2010, 1-3 July, 2010

IEDC-221-014

Economic Evaluation of Road Traffic Safety Measures

Mr. Ejaz Gul
School of Civil and Environmental Engineering

National University of Science and Technology, Islamabad, Pakistan

Email: ejazjazz@yahoo.com

Abstract

The number of road traffic casualties is still very lofty and the trend shows a boost with each passing day. The road traffic accidents involve fatalities due to which economic resources are damaged and the productivity of the economy is correspondingly impaired. Costs resulting from traffic accidents represent the largest single part of the overall cost of traffic to the economy. Knowledge about the harm of these traffic accidents to the economy is essential if measures to reduce road traffic accidents are to be identified and initiated. Once an economic assessment of road safety measures has been made, work on improving safety in accordance with economic criteria can be organized as efficiently as possible. Towards this end, it is necessary to opt for measures that are likely to be successful in a given situation. Current research is regarding the evaluation of road traffic safety measures in Pakistan and its economical effects based on available data. The research reveals that road accidents have key influence on the economic statistics of the country. The study presents a valuable tool for policy formulation on the road safety regulations in the country.

Keywords

Economic, Evaluation, Traffic, Safety, Accidents, Statistical Analysis.

1. Introduction

The transport of persons and goods by road is an essential element of modern society. At the same time such transport carries highest risks of accidents causing damage to human and resources. Safety is therefore a very important aspect of planning for road transport. Safety is of prime importance, not only to the users but also to engineers, planners and decision markers associated with operation, improvement and development of transportation system (Davis, 1993). Planning road safety measures is a complex exercise, since results and estimates varies in large way. In recent years, technical innovations have led to a steady increase in road safety measures (Hakim, 1991). Recent research has even stepped into behavioural theories and concluded that safety can be increased by improvements in human behaviour (Ghee, 1997). Education and training programmes for those using the roads can help reduce individual traffic problems. Economic dimension of road safety measure is also significant since road traffic crashes are a huge burden on the economy of countries, particularly those in low and middle-income groups (ADB, 1997). The economic cost of road crashes and injuries is estimated to be consuming roughly about

2% of the Pakistan's GDP (NHA, 2006). In this research, statistical analysis of data pertaining to efficacy of road safety measures has been evaluated to draw meaningful conclusions. The data used in this paper is related to Pakistan and may not be applicable exactly to the other regions of the world.

2. Research Methodology

A comprehensive research methology was used to carry out this study. The research approach was consisting of following steps:-

- Step 1: Appraisal of the efficacy of existing evaluation methods and selection of evaluation method for this research
- Step 2: Indentification of the nature of cost involved in the context of Pakistan.
- Step 2: Field survey for collective of data about accidents and to ascetain trends and patterns.
- Step 3: Economic evaluation of road safety measures.
- Step 4: conclusions.

3. Efficacy of the Current Evaluation Methods

Controversy exists over the choice of the correct way of evaluating road safety measures as different evaluation procedures produce different opinions and estimates (Tengs, 1995). Moreover, a generally accepted view on the economic cost of accidents has not emerged so far (Ghee, 1997). Estimates of the costs of accidents display considerable diversity. Presently following methods are available to assess the economic impacts of road safety measures:-

- Economic evaluation using cost-benefit analysis is based on the costs incurred as a result of road accidents. Avoiding such costs, through effective road safety measures, represents the economic benefit of road safety measures. A measure is macro-economically profitable, if the difference between benefits and costs is ≥ 0 or the ratio of benefits to costs is ≥ 1. This method is the most reliable, therefore, has been used in the current research.
- The "cost of damage" method determines costs through direct assessment of the damage caused by accidents. By determining the actual damage caused, this approach attempts to make an objective evaluation of the costs, based on various factors involved. This method has been used hitherto to calculate the cost of accidents around the globe (Choueiri, 1995). However, it is argued that the method can lead to ethical problems as injury may be assessed differently, depending on the individual injured and his/her contribution to production (Fouracre, 1977).
- Accidents costs can be assessed on the basis of "willingness to pay approach", which is a more accurate indication of losses to the national economy resulting from road accidents (Ghee, 1997). This approach determines financial outlay a person is prepared to accept to refrain from harmful practice or the amount a person suffering the effects of such practice is prepared to pay to prevent it. The approach establishes the payments that must be made to induce a person responsible for harmful practice to stop or an injured party to tolerate such practice (Hakim, 1991).

4. Identification of the Nature of Cost

In economic analyses of road safety measures, it is important to assess costs arising from accidents. The nature of cost is different for different areas. Calculation of the economic costs of road accidents takes account of all the consequences of an accident that lead to a loss of net product (Ghee, 1997). After detailed survey, a matrix of component elements was developed which was named after the author as Gul's matrix which is shown in Figure 1. Various related aspects are as under:-.

4.1 Restoration Costs

These are incurred where a situation is restored through recourse of medical, legal, administrative and other measures. Direct restoration costs arise from the medical and professional rehabilitation of the accident victim. Professional rehabilitation consists of measures that enable the accident victim to resume his professional activity. Indirect restoration costs arise from the attempt to settle legal matters (police costs, legal costs, insurance claims etc). In Pakistan, this type of cost takes the major share of total accident costs (NHA, 2006).

4.2 Costs Arising from Loss of Resources

This cost covers the reduction in economic net product resulting from the fact that persons injured or killed in an accident are no longer able to take part in the production process (Choueiri, 1995). Moreover, vehicles, property and materials are damaged or destroyed in road accidents which represent real capital.

4.3 Human Consequences

An accident is an experience that can have harmful psychological effects on those involved and their families. This may limit their capacity to endure stress as to make them unfit for work, and this entails an economic loss. Many accident victims have to change their way of life as a result of their experience (Cooper, 1998). This leads to a reduction in productivity. This also includes costs associated with the higher probability of future illness (Wilde, 1994).

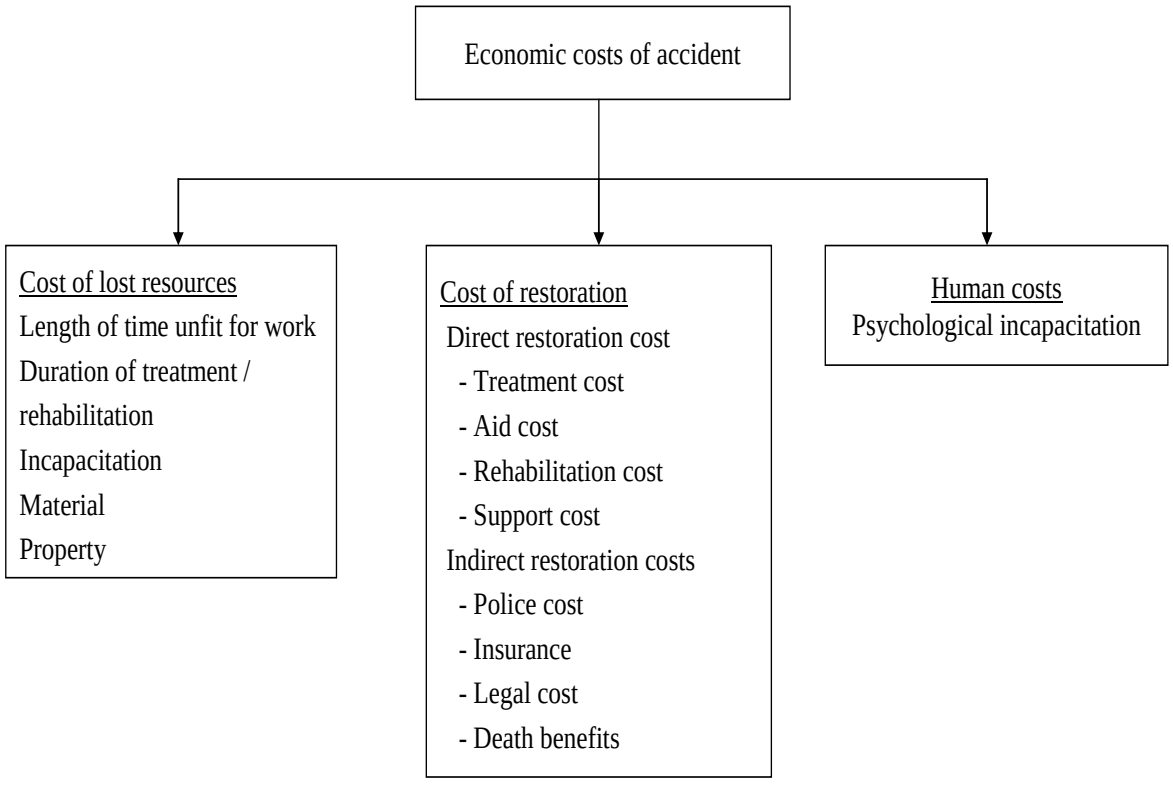

Figure 1. Gul's Chart for Nature of Cost for Economic Evaluation Process

5. Field Survey

An extensive field survey was carried out in which the data of accidents was collected from the traffic police offices at all the provincial headquarters and the capital of Pakistan. This data was then sequentially tabulated and analyzed. The results are discussed below.

5.1 Statistical Analysis of the Data

Data of accidents and fatalities from 2001 to 2009 obtained from the survey was tabulated and with the help of state of the art latest software *Stat Assist 5.3* descriptive statistics were found which reveal interesting facts and trends. Figure 2 shows a relationship between time, accidents and victims. The descriptive statistics of accidents and victims are shown in Table 1 and 2 respectively. Few important aspects from the statistical analysis of the data are as under:-

- Roughly there are about 17000 accidents of all kinds each year in Pakistan since 2001. The graph shows increasing trend of accidents with time, probably due to more number of vehicles coming in use of the citizen since 2001. The standard deviation for the accidents is high which reflects that accidents have never been less than 10000 per year.
- Roughly over 114000 people become the victim of accidents in Pakistan every year which means roughly about 300 people suffer each day. The victims include all types deaths, severe and minor injured.
- Total economic cost of accidents is estimated to be about a billion US $ every year (NHA, 2006).
- Material and property costs exceed US $200 Million per year which is neglected in most of the analysis.
- In next 12 years time, the number of accidents is likely to grow double; and the accident costs from US $ 1 billion to US $ 2.5 billion. Similarly the number of victims will be tripled making about 1000 people suffering from the accidents per day.

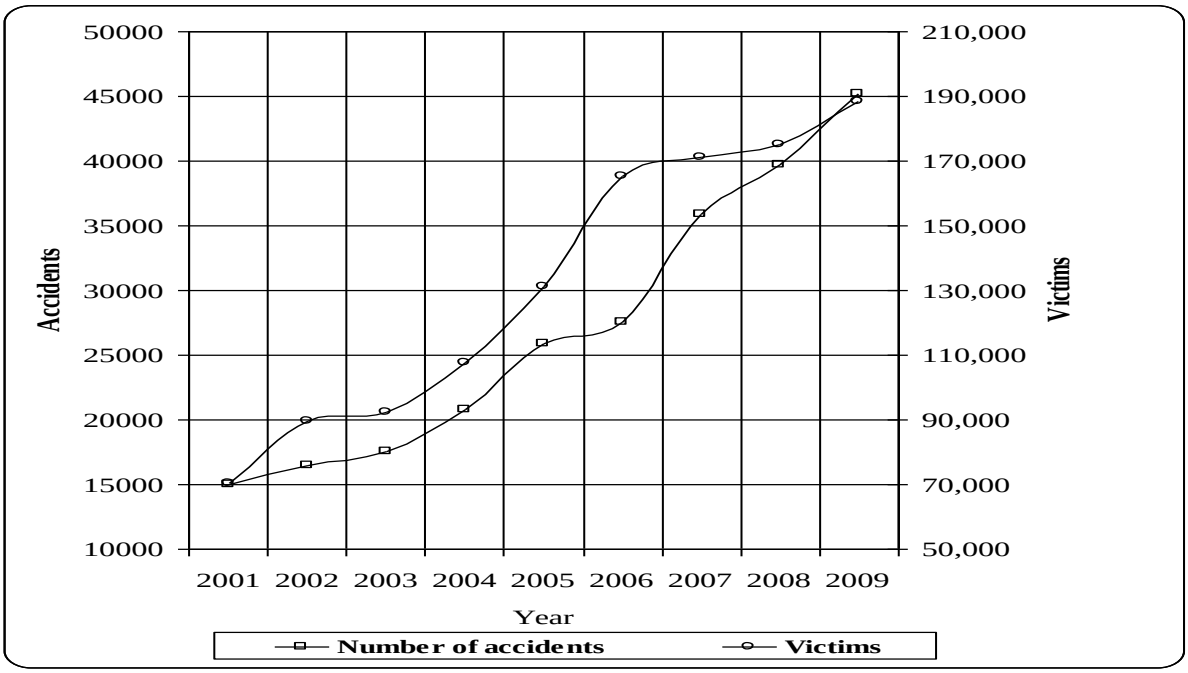

Figure 2. Relationship Between Time, Accidents and Victims

Table 1. Descriptive Statistics for the Accidents

Statistic	Value	Percentile	Value
Sample Size	9	Min	5000
Range	30179	5%	5000
Mean	17116.0	10%	5000.0
Variance	1.1936E+8	25% (Q1)	7012
Standard Deviation	10925.0	50% (Median)	15897
Coefficient of Variation	0.63831	75% (Q3)	27795
Standard Error	3641.8	90%	35179
Skew ness	0.54822	95%	35179
Excess Kurtosis	-1.1535	Max	35179

Table 2. Descriptive Statistics for the Victims

Statistic	Value	Percentile	Value
Sample Size	9	Min	70.564
Range	1.8918E+5	5%	70.564
Mean	1.1406E+5	10%	70.564
Variance	5.0453E+9	25% (Q1)	44373.0
Standard Deviation	71031.0	50% (Median)	1.3482E+5
Coefficient of Variation	0.62273	75% (Q3)	1.7087E+5
Standard Error	23677.0	90%	1.8925E+5
Skew ness	-0.95709	95%	1.8925E+5
Excess Kurtosis	-0.43401	Max	1.8925E+5

5.2 Identifying the causes of accidents

Analysis of the data reflected that road safety is affected by three main factors: man, vehicle and infrastructure. Table 3 shows the most common causes of accidents in Pakistan. It clearly emerges that in Pakistan human error is a far more frequent cause than technical failure or the condition of the infrastructure.

Table 3. Percentage Share of Causes of Accidents

Reason	Percentage
Driver's fault • Driving too fast • Not observing highway code • Driving under the influence of sleep • Disregarding pedestrians • Carelessness	84.4 28.0 25.8 10.2 3.7 16.7
Vehicle fault	5.9
Pedestrian's fault	4.2
Road conditions	3.4
Other	2.1
Total	**100.0**

The above table shows that man in the role of driver is the major cause of accidents. The accumulative share of the man (driver and pedestrian) is 88.6 %. This clearly indicates the need for training and monitoring of drivers and awareness of traffic rules in the common masses. This aspect has been neglected over the years. Moreover, lack of latest state of the art technological innovations and gadgets (shown as 2.1% in Table 1) is also emerging as a cause of accidents.

5.3 Results of Accident Cost Data Analysis

Tables 4 shows the results of accident cost analysis for Pakistan, established annually from the data obtained through field survey. By linking costs arising from accidents, with the frequency with which they occur in a year, the cost to economy due to road accidents has been worked out. Fatalities due to road accidents in a year accounted for the highest cost: more than 40 million dollars, followed by the sever injuries and the cost of damage to property and material. Overall the cost is more than a billion dollars per year.

Table 4. Results of Accident Cost Data Analysis

Category	Cost ($Million)
Personal Injury	96.75
• Fatal	43.13
• Severe	32.03
• Slight	21.59
Damage to property and material	23.22
Total	**119.97**

Personal injuries accounted for 80.65 % of the total costs per year and damage to property and material for 19.35 %. So, just as human is the man cause of accidents, human itself is the main sufferer. The cost provided in table 4, is the expenditure incurred on restoration, loss of resources and human psychological incapacitation. Its categorization is shown in Table 5.

Table 5. Categorization of the Cost Impact of Accidents

Category	Personal Injuries (Million $)			Damage to Property and Material (Million $)	Total (Million $)
	Fatal	Severe	Slight		
Restoration Costs	25.84	16.34	10.55	20.65	73.38
Loss of resources	15.09	10.78	6.98	2.57	35.42
Human Costs	2.20	4.91	4.06	-	11.17
Total	43.13	32.03	21.59	23.22	119.97

As shown in Figure 3, restoration cost takes 61 % share of the total cost per year. Restoration includes both rehabilitative and legal aspects. This is followed by cost arising from the loss of resources which comes to 30% whereas a small share of 9% is taken by the human incapacitation due to psychological reasons. In Pakistan, there is a constant increase with time in the cost arising from restoration and loss of resources. This is because of consistent increase in the cost of component elements which makes restoration and rehabilitation. The human capital is badly depleted due to accidents. It is believed that efficiency of the human being is averagely reduced by 5 – 15% even after the minor accidents for considerable period of time. From economics point of view, accident is a phenomenon which has only cost out flows and no revenue in flow.

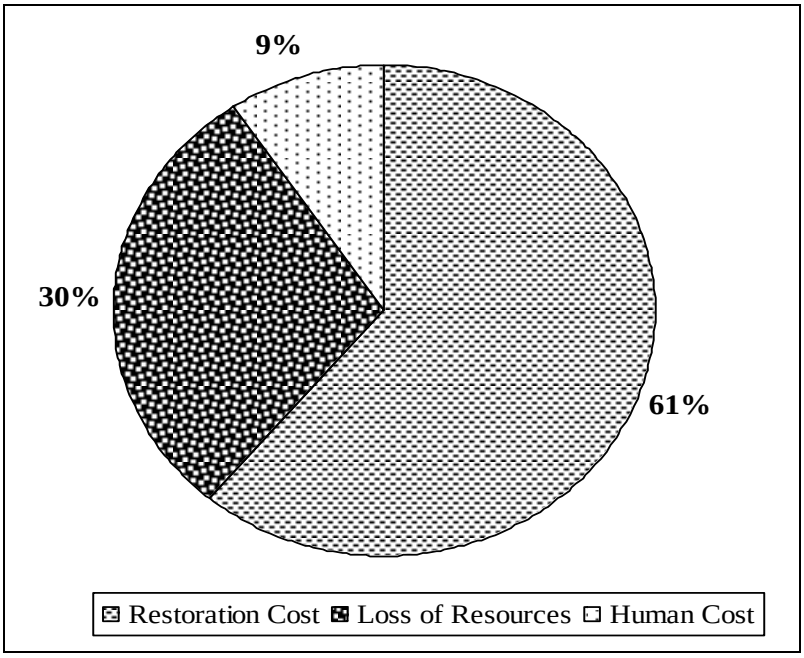

Figure 3. Percentage Share of Cost Categories

6. Economic Evaluations of Road Safety Measures

The above discussion clearly indicates that accident is a heavy burden on the national economy. To reduce the harm to manageable proportion, possible ways of reducing accidents, are implemented by each state around the globe (Hakim, 1991). The economic evaluation of these measures is essential to assess their efficacy in reduction of accidents, and hence, contribution to the economy. Table 6 shows the

potential of current road safety measures for reducing the accidents in Pakistan, based on the field survey and opinion of the masses taken on selected sites. The analysis of the current measures shows that these measures are sufficiently insufficient to control the situation. The traffic police control and speed surveillance are the two measures which are marginally effective, but overall a very weak trend can be seen in the table. The accumulative effect of these measures is not more than 60%, which indicates the huge space for improvement required in the field of traffic safety measures. Current inadequacy can be sited as the most significant reason for increase in the accidents with time instead of decrease (Figure 2). The reductions shown should be understood as potential reductions based on empirical data and not the factual.

Now let us evaluate some of the road safety measures using cost-benefit analysis (CBA). As has been stated earlier, CBA is the most reliable and effective method for economic evaluation of the road safety measures since it takes the practical and tangible facets and quantifies the intangible as well (Ghee, 1997). It is in use for evaluation of roads and communication infrastructure since 1950s and it has been used extensively for development of highways and motorways investments in the USA and UK (Hakim, 1991). CBA is simple in application as it relies on the addition of positive factors and the subtraction of negative ones to determine a net result. The accuracy of the outcome of CBA depends on how accurately costs and benefits have been estimated. Table 6 shows the CBA of all the road safety measures in terms of cost – benefit ratio (CBR) which is the ratio of benefits to costs for a particular safety measure and has to be ≥ 1 for a measure to be economically beneficial and viable.

Except for few minor safety measures, most of the measures are not viable and effective. Currently the cost on these measures is more than the benefit they are rendering in terms of reduction in the accidents. The average CBR for all measures considered in this analysis comes to be less than one, which economically undesirable. A comparison of CBR value and accident reduction percentage for each road safety measure is shown in Figure 4.

Table 6. Accident Reducing Potential and Cost Benefit Ratio of Current Road Safety Measures

Category	Measures	Accident Reduction Potential (%)	CBR
1.	Strictness in driving licensing	2	0.78
2.	Driver's fitness	3	0.54
3.	Traffic police control measures including penalties	15	0.91
4.	Compulsory wearing of safety belts	3	1.63
5.	Compulsory wearing of crash helmets	2	1.42
6.	Road maintenance	8	0.87
7.	Traffic speed surveillance	9	0.82
8.	Road guidance system / sign boards	6	0.79
9.	Vehicle fitness	3	0.65
10.	Multi lane traffic	4	0.85
11.	Side lines, pedestrian lines and restrictions	2	0.86
12.	Awareness	1	1.23
Overall Average		**58**	**0.95**

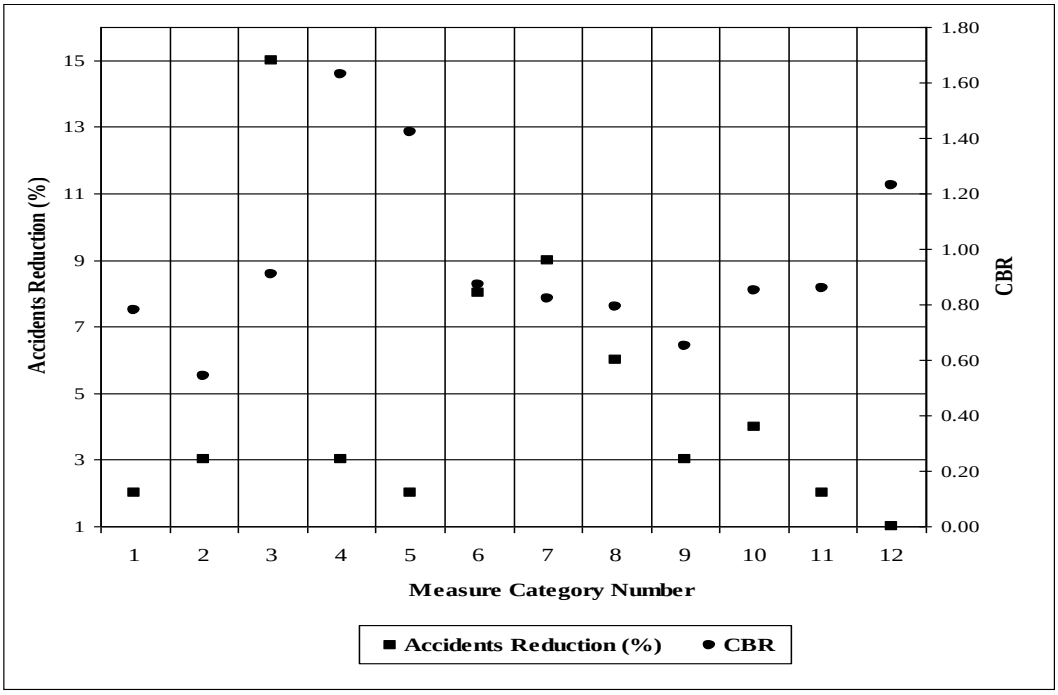

Figure 4. Trend of CBR and Accident Reduction (%) for Each Type of Road Safety Measure

Figure 4 indicates that although traffic control measures are effective in reduction of accidents but these are not economically viable. Similarly, small measures such as wearing of safety belt, using crash helmets and traffic awareness are economical and effective as they reduce accidents costs.

7. Conclusions

Based on the data available, this study has provided an economic evaluation of the current road safety measures. It has also, shown the weaknesses of the existing measures and the need to put system worthy and beneficial. The following points show possible limitations and areas of emphasis for future in the context of Pakistan:-

- Studies of costs arising from road accidents reveal considerable differences in scope and composition. For example, damage to property is often not taken into account in the calculation of accident costs, although they account for a considerable proportion – over 19% of overall accidents costs.
- Differences in accident cost levels also result from the fact that the cost components and evaluation procedures used in the calculations are not always the same. The origin of data is not always clear which makes comparison and judgment difficult. The information available for assessing the measures is sometimes incomplete. The functional connections between traffic parameters (for example kilometer performance, speed) and the frequency and seriousness of accidents are not always apparent.
- Priority needs to be given to the collection of road accident data. This information can then be used to assess the relative importance of the problem from both an economic and social view point. For this purpose a computerized accident data base centre may be established.
- Assessment of accident cost should be reviewed each year and accordingly suitable measures may be taken to reduce these costs. The economic costs of road crashes are, in general, not well

understood as much of the cost is hidden and incurred in small-scale crashes rather than in large incidents.

The current study shows that the implementation of certain road safety measures could develop the potential for safety even further. This potential is associated with technological and legal measures, as well as those that address behaviour:

- Traffic awareness has shown one of the best cost-benefit results. This area needs to be exploited.
- As regards legal measures, the requirement to wear seat belts and helmets is proving to have a significant effect on road safety while also being more cost-effective.
- A further tightening on licensing, driver's health and vehicle fitness is also regarded by many experts as an effective way of improving road safety.
- If the accident reduction target alone is considered, we might expect speed restrictions to have a significant effect on road safety. Unfortunately, the available data on the cost effectiveness of speed restrictions is not very encouraging. Investigations carried out suggest that such a measure would lead to higher costs, resulting mainly from loss of time.
- Technological innovations also promise further improvements in road safety. This involves measures taken both inside and outside the vehicle. The critical point is that technological improvements are often associated with significant costs, which mean unsatisfactory cost benefit ratios.
- The traffic rules and regulations need to be enforced in true letter and spirits. This has the maximum accident reduction potential in the developing societies.

References

Asian Development Bank (1997). Road safety guidelines for the Asia and Pacific region. Asian Development Bank, Manila.

Choueiri E M, Choueiri G M and Choueiri B M (1995). Some aspects of road safety problems in developing countries: a case study. *Proceedings of 1995 VTI Conference, 5A Part 1, Birmingham, 4-12.*

Cooper R S, Osotimehin B, Kaufman J, and Forrester T (1998). Disease burden in sub-Saharan Africa: what should we conclude in the absence of data? *The Lancet, Vol 351*, January 17, 1998, 208-210.

Davis R (1993). Death on the streets: cars and the mythology of road safety. Leading Edge, North Yorkshire.

Fouracre P R and Jacobs G D (1977). Comparative accident costs in developing countries. *Supplementary Report SR270*. Transport Research Laboratory, Crowthorne.

Hakim S, Shefer D, Hakkert AS and Hockerman I, 1991. A critical review of macro models for road accidents, Accident analysis and prevention, Volume 23, Number 5, pp 379-400.

Ghee C, Silcock D, Astrop A and Jacobs G D (1997).Socio economic aspects of road accidents in developing countries. *TRL Report TRL247*. Transport Research Laboratory, Crowthorne.

NHA (2006). Road accidents in Pakistan. National Highway Authority.

Tengs, O. T., Adams, M. E., Pliskin, J. S. et al. (1995), Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness, in: Risk Analysis, Vol. 15, No. 3.

Wilde GS, 1994. Target risk: Dealing with the danger of death, disease and damage in everyday decisions, PDE Publications, Ontario, Canada.